

Evaluation of the Maxillary Dental Midline Relative to the Face

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A thesis submitted to the faculty of the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Master of Science in the School of Dentistry (Orthodontics).

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ABSTRACT

David A. Rothas: Evaluation of the Maxillary Dental Midline Relative to the Face
(Under the direction of Dr. Ceib Phillips)

A general principle of smile design is the maxillary dental midline should coincide with the center of the face. However, little data is available to indicate where to position the maxillary dental midline for patients with asymmetrical faces to optimize dentofacial esthetics. The first manuscript describes lay people and dentists' preferred maxillary dental midline position for symmetrical and asymmetrical faces. The results suggested that overall facial esthetics may be improved for patients with facial asymmetries by slightly deviating the maxillary dental midline from center. The second manuscript compares the concordance of twelve techniques for describing the position of the maxillary dental midline relative to the face with respondents' average preferred maxillary dental midline position for a symmetrical and 22 asymmetrical faces. A novel method that calculates the position of maxillary dental midline based on the position of the nose, cupid's bow, mouth and chin had the highest degree of concordance.

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1. INTRODUCTION

A generally accepted principle of smile design is that the maxillary dental midline should be aligned with the center of the face.^{1, 2} This is a reasonable guideline for a symmetrical patient whose nose, cupid's bow, mouth and chin are all coincident with the midsagittal plane. However, not all patients have symmetrical faces.³⁻⁹ This has led to some confusion about where to position the dental midline in patients with deviated facial structures and which technique is the most reliable method for describing the position of the teeth relative to symmetrical and asymmetrical faces.¹⁰

The purpose of the first paper, *Lay People and Dentists' Preferred Maxillary Dental Midline Position for Symmetrical and Asymmetrical Faces – An Internet-based Study*, was to evaluate the preferred maxillary dental midline position for a series of digitally-altered symmetrical and asymmetrical faces. The specific aims were to: 1) determine if respondents would alter the position of the maxillary dental midline to compensate for the transverse discrepancies in the position of the tip of the nose, cupid's bow, mouth and chin; 2) estimate to what extent the maxillary dental midline would be altered to compensate for transverse deviations of these structures; and 3) determine if there was any difference in preference of the maxillary dental midline position between respondents based on professional status (lay people, general dentists and orthodontists).

The purpose of the second paper, *Comparison of Techniques for Describing the Position of the Maxillary Dental Midline Relative to the Face in Symmetrical and Asymmetrical Patients*, was to compare the concordance of twelve techniques for describing

the position of the maxillary dental midline relative to the face with the respondents' average preferred maxillary dental midline position for a symmetrical face and 22 images in which facial midline structures deviated 3mm to the right or left. The objective was to identify a technique that could be used to assess the position of the maxillary dental midline in both the symmetrical and asymmetrical patients.

**Lay People and Dentists' Preferred Maxillary Dental Midline Position for
Symmetrical and Asymmetrical Faces – An Internet-based Study**

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2.1 ABSTRACT

Purpose: The purpose was to evaluate the preferred maxillary dental midline position for a series of symmetrical and asymmetrical faces. The specific aims were to: 1) determine if respondents would alter the position of the maxillary dental midline to compensate for the transverse discrepancies in the position of the tip of the nose, cupid's bow, mouth and chin; 2) estimate to what extent the maxillary dental midline would be altered to compensate for transverse deviations of these structures; and 3) determine if there was any difference in preference of the maxillary dental midline position between respondents based on professional status (lay people, general dentists and orthodontists).

Methods: 100 lay people, 58 general dentists and 119 orthodontists participating in an internet-based survey viewed a series of digitally altered photographs, each representing a different combination of mild facial asymmetry, and moved the teeth to the location where the maxillary dental midline and face looked best.

Results: Respondents moved the position of the maxillary dental midline in response to changes in the position of the tip of the nose, cupid's bow, mouth and chin. The average preferred maxillary dental midline ranged from 1.8 mm to the right to 1.3 mm to the left based on the combination of asymmetrical facial features. On average, for a 3 mm deviation of the mouth respondents moved the maxillary dental midline 0.7 mm in the same direction as the mouth deviation. The average effect for a 3 mm movement of the nose, cupid's bow and chin was 0.6 mm, 0.4 mm and 0.3 mm, respectively. The differences between the

respondent groups were small and probably not of clinical significance. Overall, the trends were consistent across all three respondent groups.

Conclusion: The results of this study suggest that overall facial esthetics may be improved for patients with transverse facial asymmetries by displacement of the maxillary dentition.

2.2 INTRODUCTION

A generally accepted principle of smile design is that the maxillary dental midline should be aligned with the center of the face.^{1,2} This is a reasonable guideline for a symmetrical patient whose nose, cupid's bow, mouth and chin are all coincident with the midsagittal plane. However, not all patients have symmetrical faces³⁻⁹ which has led to some confusion about where to position the dental midline in patients with deviated facial structures.¹⁰ For patients with asymmetrical faces, it has been stated that the dental midline should be placed in the center of the face to detract attention from the deviated facial structures.¹ The counterargument could be made that displacing the maxillary dental midline may make a facial discrepancy less apparent. Unfortunately, there is very little data to suggest the preferred maxillary dental midline position for patients with a deviation of the nose, cupid's bow, mouth or chin.

Beyer and Lindauer conducted a study using two sets of four facial photographs: the first set consisted of a symmetrical face and three faces with the nose, philtrum or chin deviated 2.8 mm to the right; and a second set with the maxillary dental midline in each image also deviated 2.8 mm to the right. Respondents ranked the photographs in which the dental midline was centered as more esthetic than the images with the deviated midline.¹¹ This finding may indicate that altering the maxillary dental midline is not a satisfactory option to camouflage a skeletal or soft tissue facial asymmetry in the transverse plane. An alternative explanation is that the 2.8 mm dental midline deviation was outside the envelope of acceptable dental esthetics. Perhaps altering the dental midline by a lesser magnitude would have produced adequate dental esthetics and improved the overall dentofacial esthetics.

The purpose of this internet-based survey was to evaluate the preferred maxillary dental midline position for a series of digitally-altered symmetrical and asymmetrical faces. The specific aims were to: 1) determine if respondents would alter the position of the maxillary dental midline to compensate for the transverse discrepancies in the position of the tip of the nose, cupid's bow, mouth and chin; 2) estimate to what extent the maxillary dental midline would be altered to compensate for transverse deviations of these structures; and 3) determine if there was any difference in preference of the maxillary dental midline position between respondents based on professional status (lay people, general dentists and orthodontists).

2.3 METHODS

An internet-based survey was created that allowed respondents to view digitally-altered symmetrical and asymmetrical full-face images and change the horizontal position of the maxillary dental midline. The development of the survey involved the following steps: 1) creating a digitally-altered symmetrical face and a series of asymmetrical faces; 2) altering the position of the maxillary dental midline position for each face created; 3) incorporating the images into a secure, web-based application that allowed users to view a facial image and control the position of the maxillary dental midline; and 4) distributing the survey to three respondent groups (lay people, general dentists and orthodontists). This research study was approved by the Biomedical Institutional Review Board.

1) Creation of Symmetrical and Asymmetrical Facial Images. A full-face digital photograph was captured of a smiling, female volunteer with good dental alignment. This photo was digitally altered to create a perfectly symmetrical facial image. The symmetrical facial image was then used to create 24 combinations of facial asymmetry by digitally altering the position of the tip of the nose, cupid's bow, mouth and chin. The facial features were morphed to the right or left to reflect a 3 mm deviation. For two of the asymmetrical faces, cupid's bow was altered by either 1 mm or 2 mm to the right. The 25 different facial combinations used in this study are described in Table 2.1 and a sample of the facial images is shown in Figure 2.1.

Three pairs of facial images were mirror images of one another. For example, facial image B (cupid's bow 3 mm to the right) was the mirror image of facial image C (cupid's bow 3 mm to the left). The other mirror image pairs were facial images G - M and L - K.

2) Alteration of the Maxillary Dental Midline Position. For each facial image

described in Table 2.1, 12 additional images were made with the maxillary dental midline position moved to the right and left in 1 mm increments up to 6 mm. The completed facial image sets each consisted of 13 images (the original with the maxillary dental midline centered, the 6 deviations to the right and the 6 deviations to the left). The maxillary dental midline position was altered by digitally translating the teeth around the original arch form, not by transversely moving the maxillary dentition as a single unit. As the maxillary dental midline moved laterally following this procedure the display of the canines and premolars became asymmetrical, but the buccal corridor space remained symmetrical bilaterally. The centered maxillary dental midline and each of the 1 mm incremental deviations to the left for the symmetrical face, facial image A, are shown in Figure 2.2 (the deviations to the right are mirror images and not shown due to limited space).

The final color images were 65% of life size. The images were prepared at 72 dpi and saved as compressed 56 kb jpeg files. All photo editing was accomplished with Adobe Photoshop 6.0 for Windows (Adobe Systems Inc., San Jose, CA).

3) Development of the Internet-based Survey. A secure, internet-based survey was developed that permitted users to view the full-face image sets and change the horizontal position of the maxillary dental midline. Respondents were instructed to move the maxillary dental midline to the position where they felt the teeth and face looked best. The users changed the maxillary dental midline position in 1 mm increments by pressing the left and right keyboard arrow keys or by clicking the mouse cursor on a left and right directional button. The maxillary dental midline position always started at 6 mm to the right. The position of the preferred maxillary dental midline for each of the 25 facial image sets was recorded as a value from -6 mm (right of center) to +6 mm (left of center). Zero was

recorded if the original symmetrical maxillary midline position was selected. The outcome measure was treated as a discrete, continuous variable. Respondents saved their selection by pressing the enter key or clicking on the “next question” button with the mouse. The order that the different facial image sets were displayed was randomly determined by the software application. The lay people evaluated facial image set E twice. The general dentists and orthodontists evaluated facial image sets A, H, and U twice. Intraexaminer reliability of the preferred maxillary dental midline position was estimated using the Intraclass Correlation Coeffecient (ICC).

The respondents were asked to evaluate four full-face images and mark, with a small vertical cursor line, the tip of the nose or the center of the chin in a symmetrical facial image and images with the nose or chin deviated 3 mm to the right. The difference between the symmetrical and deviated position was used to assess how accurately the deviation in the morphed facial features could be discerned by the respondents.

4) Respondents. The survey was completed by lay people, general dentists and orthodontists. The lay people consisted of parents of patients and adult patients of the Department of Orthodontics at the University of North Carolina School of Dentistry. The individuals were approached in the waiting area and invited to participate in the survey. A computer and a private consultation room were provided to the lay people to complete the survey. The orthodontist and general dentist groups consisted of practitioners with North Carolina dental licenses. Their names and contact information were obtained from the North Carolina Board of Dental Examiners. All orthodontists on the list with a valid address and an equal number of randomly selected general dentists were invited by letter to participate in the survey. Two additional follow-up letters were mailed at three week intervals to those who

did not complete the survey. Respondents were given a unique, single-use identification number and a password to gain access to the survey. Respondents were asked to provide general demographic data. All response data were automatically saved and stored by the internet-based application on a secure server.

STATISTICAL ANALYSIS

Mirror Images. Paired t-tests of the preferred maxillary dental midline position of the mirror facial images (facial image B vs. C, G vs. M, and L vs. K) were used to assess whether the direction of the facial deviation systematically affected the responses.

Effect of Individual Facial Features. Facial image sets that differed by the position of only one facial feature were paired (10 pairs for the nose; 13 for cupid's bow; 4 for the mouth; and 11 for the chin). For example, the only difference between facial image A and facial image H is the position of the nose; the nose is centered in image A but deviated to the left by 3 mm in image H. For all pairs, one facial feature was centered and the other was deviated to the left or right by 3 mm. The difference between the preferred maxillary dental midline positions of the paired images was calculated for each respondent. The difference was designated as positive if the preferred maxillary dental midline position moved in the same direction as the deviated facial feature and negative if the preferred maxillary dental midline position moved in the opposite direction. Descriptive statistics were calculated for the difference between the preferred maxillary dental midline positions for each facial image pair.

Comparison of Respondent Groups. For each respondent, the average of the differences between the maxillary dental midline positions for the centered and deviated pairs was calculated for each of the facial features. An analysis of variance (ANOVA) and

contrast tests were used to compare, for each facial feature, the average effect of a 3 mm deviation on the preferred maxillary dental midline position between the respondent groups (lay people, general dentists and orthodontists).

Level of significance was set at 0.05. All statistical analyses were performed using SPSS 13.0 (SPSS Inc., Chicago, IL).

2.4 RESULTS

Respondents. A total of 277 individuals completed the survey. The response rate was highest for the lay people (Table 2.2). The average age of the three groups were similar but there was a higher proportion of males in the practitioner groups. The education level of the lay people was comparable to that of the local community (local: 87.6% high school degree and 51.5% college degree).¹² The majority of the practitioners completed their dental school or specialty training at UNC or an east-coast dental program (Table 2.2).

Intraexaminer Reliability. The overall intraexaminer reliability within each of the three groups was excellent. The ICC for the lay people was .76 for the one image that was replicated while the ICC for the practitioner groups ranged from .71 to .89. The measures of intrexaminer reliability for the three groups are summarized in Table 2.3.

Evaluation of Morphed Nose and Chin. On average, respondents marked the tip of the nose in the symmetrical image as 0.1 ± 0.4 mm to the left of center while the tip of the nose in the image with the nose deviated 3 mm to the right was located 2.8 ± 0.7 mm to the right. The average locations for the chin were quite similar: in the symmetrical image the center of the chin was located 0.1 ± 0.6 mm to the left of center and in the image with the chin deviated 3 mm to the right of center the chin was located 2.8 ± 0.9 mm right of center.

Mirror Images. There was no statistically significant difference ($P \geq 0.16$) in the preferred midline position for any of the 3 mirror image pairs. The difference between the mirror images ranged from 0.0 mm to 0.1 mm. See Table 2.4.

Preferred Maxillary Dental Midline Position for Each Facial Image Set. For the perfectly symmetrical face, the majority of all respondents (70% of the lay people; 88% of

the general dentists; and 89% of orthodontists) preferred the maxillary dental midline in the center and no respondent preferred the midline greater than 1 mm from the facial midline.

Of all the image sets, the preferred maxillary dental midline location was the most deviated for image V (nose, cupid's bow and mouth all deviated to the right 3 mm and chin centered). Only 4% of all respondents preferred the midline in the center, 29% preferred the midline 1 mm to the right, 57% 2 mm to the right and 10% 3 mm to the right. No individual preferred the midline to the left of center for facial image V.

The mean preferred maxillary dental midline position for each of the facial images is reported by respondent group in Table 2.5 and Figure 2.3. The average preferred dental midline position tended to deviate from center for the asymmetrical images, particularly when multiple facial structures deviated to the same side. This trend was observed for all three respondent groups despite small differences in the actual mean preferred midline position.

Effect of Individual Facial Features. From the pairs of images that differed only by the position of a single facial feature, the average effect of a 3 mm deviation of the mouth and nose had the most influence on the preferred midline position in all three groups and the deviation of cupid's bow and the chin had the least influence (Table 2.6 and Figure 2.4).

Comparison of Respondent Groups. The average effect of a 3 mm facial feature deviation on the preferred maxillary dental midline position differed significantly among the respondent groups ($P \leq 0.01$ for all facial features, Table 2.6 and Figure 2.4). The average deviation of the preferred midline position for the lay group differed significantly from that of the orthodontists for all facial features ($P \leq 0.02$). The average deviation of the midline position for the lay group differed from the general dentists for cupid's bow and the chin

($P \leq 0.02$) but not for the nose ($P = 0.68$) and mouth ($P = 0.51$). The average deviation of the midline position did not differ significantly between the general dentists and the orthodontists when the center of the chin was deviated 3 mm ($P = 0.86$) but was significantly different when the nose, cupid's bow, or mouth ($P \leq 0.04$) were deviated 3 mm from center.

2.5 DISCUSSION

A certain degree of facial asymmetry exists in almost all faces.³⁻⁹ For the non-growing patient, and even perhaps the growing patient, the only method to correct facial discrepancies is through surgery. Despite the touted benefits of facial surgery combined with orthodontic treatment¹³ many patients are reluctant or unable to undergo adjunctive surgical treatment. An alternative to surgery is to camouflage the underlying skeletal or soft tissue discrepancy by displacing the teeth relative to their supporting bone in order to make the facial asymmetry less apparent.¹⁴ Very little information is available in the dental literature on the extent to which altering the horizontal position of the maxillary dentition can be used to camouflage facial discrepancies in the transverse plane.

The purpose of this study was to evaluate the preferred maxillary dental midline position for symmetrical and asymmetrical faces. The internet-based application developed proved to be a reliable survey instrument. Respondents were able to accurately discern the position of the nose and chin in both the symmetrical and asymmetrical images. This is consistent with the results of Beyer and Lindauer who reported that morphed facial deviations of 2.8 mm were detectable to most evaluators.¹¹ There was also an excellent degree of concordance between the repeated dental midline assessments for all respondent groups and the direction of the facial deviation (right versus left) did not systematically bias the preferred dental midline position.

In this study respondents did move the position of the maxillary dental midline in response to changes in the position of the tip of the nose, cupid's bow, mouth and chin. The average preferred maxillary dental midline ranged from 1.8 mm to the right to 1.3 mm to the left based on the combination of asymmetrical facial features (Figure 2.3). The greatest

change in the preferred maxillary dental midline position was observed when multiple facial features deviated to the same side; the preferred dental midline was altered less when two facial features deviated in opposite directions or when only one facial feature was deviated. The average effect of a single facial feature deviating 3 mm from center was a slight (less than 1 mm) movement of the preferred maxillary dental midline in the same direction. The differences between the respondent groups were small and probably not of clinical significance. Overall, the trends were consistent across all three respondent groups.

The results of this study suggest that overall facial esthetics may be improved for patients with transverse facial asymmetries by displacement of the maxillary dentition. This finding has not been reported before in the dental literature. In contrast, Beyer and Lindauer concluded that the maxillary dental midline position should be determined independently of the location of specific facial landmarks.¹¹ However, this conclusion was based on the unfavorable ratings of 2.8 mm facial discrepancies masked by moving the maxillary dentition 2.8 mm. A similar finding in the current study was that no respondent preferred the maxillary dental midline deviated 3 mm to compensate for a 3 mm movement of the nose; 1.4% and 0.4% of the respondents moved the maxillary dental midline 3 mm in response to a 3mm movement of cupid's bow and the chin, respectively. It is likely that any esthetic benefit gained by camouflaging the facial asymmetry in these situations is offset by the unaesthetic dental appearance of the 3 mm deviation of the maxillary dental midline.

A degree of caution should be exercised when generalizing these results. The results of this study were based on evaluations of two-dimensional images of a Caucasian female with morphed facial features and teeth. Variations between individuals in the size, shape or prominence of facial features may influence the degree to which facial asymmetries could be

camouflaged.¹⁵ The facial features in this study all deviated 3 mm from center except for 2 facial images, X and Y. Facial deviations greater or less than 3 mm may not have a linear effect on the preferred maxillary dental midline position. It is unknown how individuals would respond to a nasal deviation of 4 mm or 5 mm. There may be facial features to consider in addition to the nose, cupid's bow, mouth and chin.

2.6 CONCLUSION

The position of the maxillary dental midline was moved by respondents in response to changes in the position of the tip of the nose, cupid's bow, mouth and chin. Respondents moved the maxillary dental midline most to compensate for discrepancies in the position of the mouth and nose and least for the chin and cupid's bow. There was not a one to one correlation between the preferred position of the maxillary dental midline and any single facial feature. There was generally good agreement between the lay people, general dentists and orthodontists in their perceptions. Although some of the differences between the respondent groups were statistically significant these differences were quite small and not likely to be clinically significant. Clinicians should view the full face and consider the position of the nose, cupid's bow, mouth and chin when diagnosing the position of the maxillary dental midline.

Table 2.1. Facial Combinations Created by Altering Four Facial Features (Nose - N, Cupid's Bow - CB, Mouth - M and Chin - Ch) to Three Locations (Right, Center and Left). The magnitude of all movements equaled 3 mm except where otherwise noted*.

Image	Right	Centered	Left
A		N,CB,M,Ch	
B	CB	N,M,Ch	
C		N,M,Ch	
D	Ch	N,CB,M	
E	CB,Ch	N,M	
F	Ch	N,M	CB
G	N,CB,Ch	M	
H		CB,M,Ch	N
I	CB	M,Ch	N
J		CB,M	N,Ch
K	N,Ch	M	CB
L	CB	M	N,Ch
M		M	N,CB,Ch
N		M,Ch	N,CB
O	Ch	CB,M	N
P	CB,Ch	M	N
Q	Ch	M	N,CB
R	M	N,CB,Ch	
S	CB,M	N,Ch	
T	M,Ch	N,CB	
U	N,M	CB,Ch	
V	N,CB,M	Ch	
W	CB,M,Ch	N	
X*	CB (1mm)	N,M,Ch	
Y*	CB (2mm)	N,M,Ch	

Table 2.2. Response Rate and Respondent Information.

Group	N	Response Rate	Age (years) Mean ± SD Range	Male	Schooling	Yrs in Practice Mean ± SD	Clinical Hrs/Wk Mean ± SD
Lay People	100	96.2%	42.7 ± 10.6 18-73	50%	<i>Degree</i> High School: 100 % College: 50%		
General Dentists	58	29.0%	46.8 ± 10.8 29-74	82.8%	<i>Dental School</i> UNC: 65.5% Other: 34.5%	19.9 ± 11.1	29.8 ± 10.8
Orthodontists	119	59.5%	49.0 ± 12.7 27-83	87.4%	<i>Orthodontic Program</i> UNC: 52.1% Other: 47.9%	18.6 ± 12.0	27.9 ± 9.8

Table 2.3. Intraexaminer Percent Agreement and Intraclass Correlation Coefficient (One-Way Random) of Repeat Evaluations.

Image	Group	N	Percent Agreement	ICC	95% Confidence Int. Lower	Upper
A	General Dentists	58	93.1	.75	.62	.85
	Orthodontists	110	97.3	.89	.84	.92
H	General Dentists	58	82.8	.71	.56	.82
	Orthodontists	110	91.8	.86	.80	.90
U	General Dentists	58	79.3	.71	.56	.82
	Orthodontists	110	85.5	.80	.72	.86
E	Lay People	100	78.0	.76	.66	.83

Table 2.4. Comparison of Preferred Midline Location for Mirrored Facial Image Sets.

Facial Image Pairs	Lay People N = 100		General Dentists N = 58		Orthodontists N = 119		Combined Responses N = 277	
	Difference of Means \pm SD (mm)	P value*	Difference of Means \pm SD (mm)	P value	Difference of Means \pm SD (mm)	P value	Difference of Means \pm SD (mm)	P value
B – C	0.1 \pm 1.1	.21	0.0 \pm 0.7	.86	0.0 \pm 0.7	.90	0.0 \pm 0.9	.28
G – M	0.1 \pm 1.1	.48	0.0 \pm 0.7	.86	0.1 \pm 1.1	.55	0.0 \pm 1.0	.41
K – L	0.1 \pm 1.3	.58	0.1 \pm 0.9	.58	0.1 \pm 1.1	.16	0.0 \pm 1.1	.46

* For each facial mirror image pair, paired t-tests were used to compare the preferred midline positions of the mirror images.

Table 2.5. Preferred Maxillary Midline Location for Each Image by Respondent Group.

Image	Position of Facial Feature			Lay People N = 100		General Dentists N = 58		Orthodontists N = 119	
	3mm Right	Centered	3mm Left	Mean (mm)	S.D.	Mean (mm)	S.D.	Mean (mm)	S.D.
A		N,CB, M, Ch		L 0.1	0.5	C 0.0	0.4	C 0.0	0.3
B	CB	N, M, Ch		R 0.5	0.9	R 0.3	0.5	R 0.5	0.7
C		N, M, Ch	CB	L 0.6	0.8	L 0.4	0.6	L 0.5	0.6
D	Ch	N, CB, M		R 0.1	0.7	R 0.3	0.7	R 0.2	0.6
E	CB, Ch	N, M		R 0.6	0.7	R 0.6	0.8	R 0.7	0.8
F	Ch	N, M	CB	L 0.4	0.9	R 0.1	0.6	C 0.0	0.7
G	N, CB, Ch	M		R 1.3	0.9	R 1.0	0.5	R 1.4	0.7
H		CB, M, Ch	N	L 0.6	0.7	L 0.5	0.6	L 0.5	0.6
I	CB	M, Ch	N	L 0.3	1.0	L 0.2	0.7	L 0.3	0.8
J		CB, M	N, Ch	L 0.7	0.7	L 0.7	0.8	L 0.8	0.7
K	N, Ch	M	CB	R 0.4	0.9	R 0.7	0.7	R 0.7	0.9
L	CB	M	N, Ch	L 0.3	1.0	L 0.7	0.7	L 0.6	0.8
M		M	N, CB, Ch	L 1.3	0.9	L 1.0	0.7	L 1.3	0.7
N		M, Ch	N, CB	L 1.2	0.8	L 0.8	0.8	L 1.0	0.8
O	Ch	CB, M	N	L 0.4	0.7	C 0.0	0.8	L 0.2	0.7
P	CB, Ch	M	N	R 0.1	1.0	R 0.1	0.8	C 0.0	0.8
Q	Ch	M	N, CB	L 0.9	0.8	L 0.5	0.8	L 0.7	0.8
R	M	N, CB, Ch		R 0.7	0.6	R 0.9	0.7	R 0.6	0.5
S	CB, M	N, Ch		R 1.3	0.9	R 1.0	0.7	R 1.0	0.7
T	M, Ch	N, CB		R 0.8	0.7	R 1.1	0.7	R 0.9	0.6
U	N, M	CB, Ch		R 1.2	0.7	R 1.7	0.6	R 1.3	0.6
V	N, CB, M	Ch		R 1.7	0.8	R 1.8	0.7	R 1.8	0.6
W	CB, M, Ch	N		R 1.3	0.8	R 1.3	0.7	R 1.2	0.7
X*	CB (1mm)	N, M, Ch		R 0.2	0.7	R 0.3	0.5	R 0.3	0.7
Y*	CB (2mm)	N, M, Ch		R 0.3	0.8	R 0.2	0.5	R 0.3	0.6

C – Center, L – Left of Center, R – Right of Center

N – Nose, CB – Cupid's Bow, M – Mouth, Ch – Chin

Table 2.6. Comparison of Average Difference in Preferred Maxillary Midline Location as a Result of a 3 mm Change in the Position of a Single Facial Feature. Combined ANOVA and ANOVA Contrast Test Significance (2-tailed).

Facial Feature	Mean Difference ± SD (mm)			ANOVA	ANOVA Contrast Test Sig. (2-tailed)		
	Lay People	General Dentists	Orthodontists		Lay People - General Dentists	Lay People - Orthodontists	Orthodontists - General Dentists
Nose	0.6 ± 0.3	0.5 ± 0.3	0.7 ± 0.3	.01	.68	.01	.01
Cupid's Bow	0.5 ± 0.5	0.2 ± 0.3	0.4 ± 0.4	<.01	< .01	.02	.03
Mouth	0.8 ± 0.5	0.8 ± 0.4	0.6 ± 0.4	<.01	.51	.01	.04
Chin	0.2 ± 0.2	0.3 ± 0.3	0.3 ± 0.3	<.01	.02	< .01	.86

Figure 2.1. Sample of Morphed Facial Features. A) Symmetrical Face. B) Cupid's Bow 3 mm Right. D) Chin 3 mm Right. H) Nose 3 mm Left. R) Mouth 3 mm Right. V) Nose, Cupid's Bow and Mouth 3 mm Right.

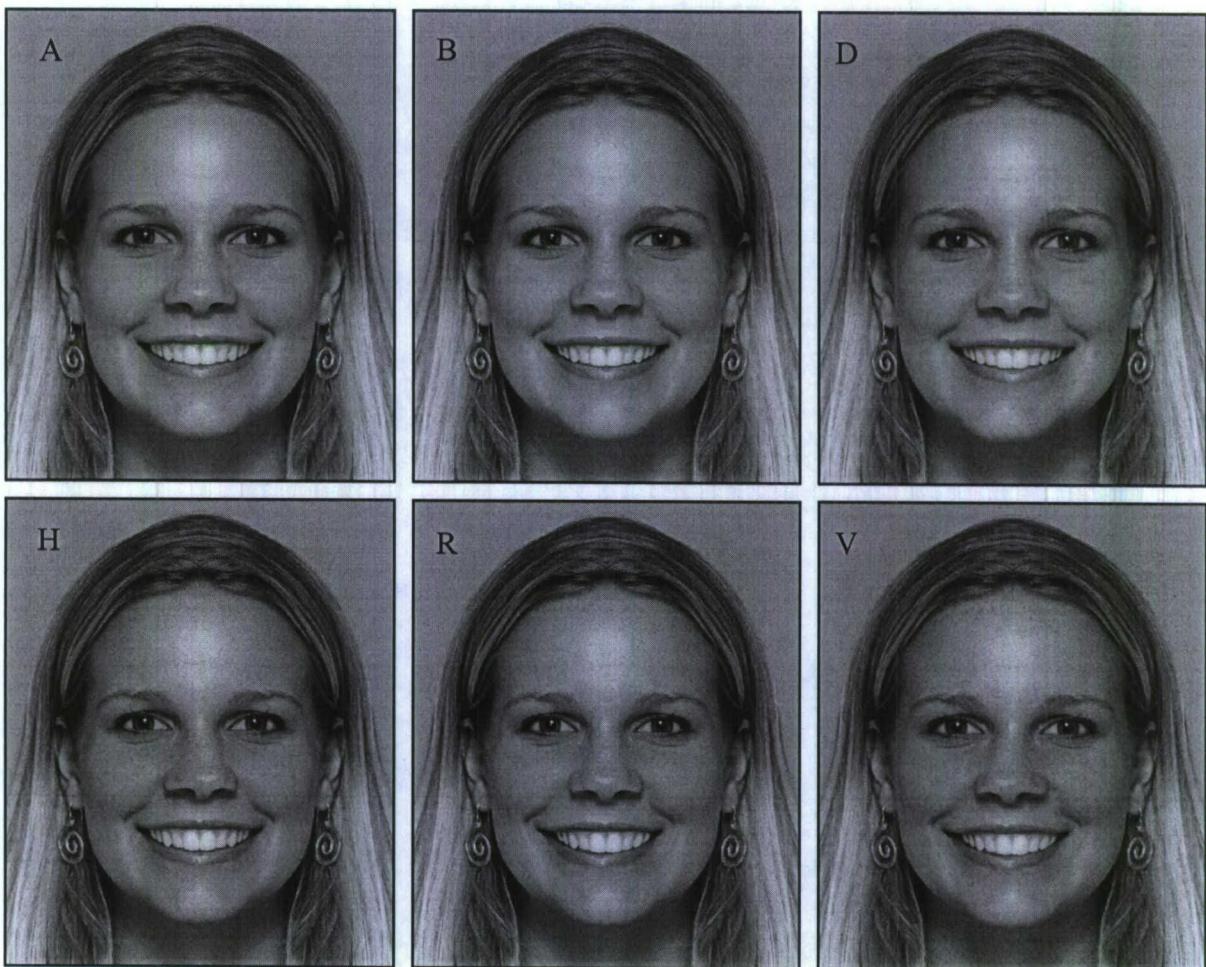


Figure 2.2. Symmetrical Face, Image Set A, with the Maxillary Dental Midline Deviated up to 6 mm to the Left.



Figure 2.3. Preferred Maxillary Dental Midline Position for 25 Different Facial Image Sets for the Lay People, General Dentists and Orthodontists (mm, Mean \pm 1 SD).

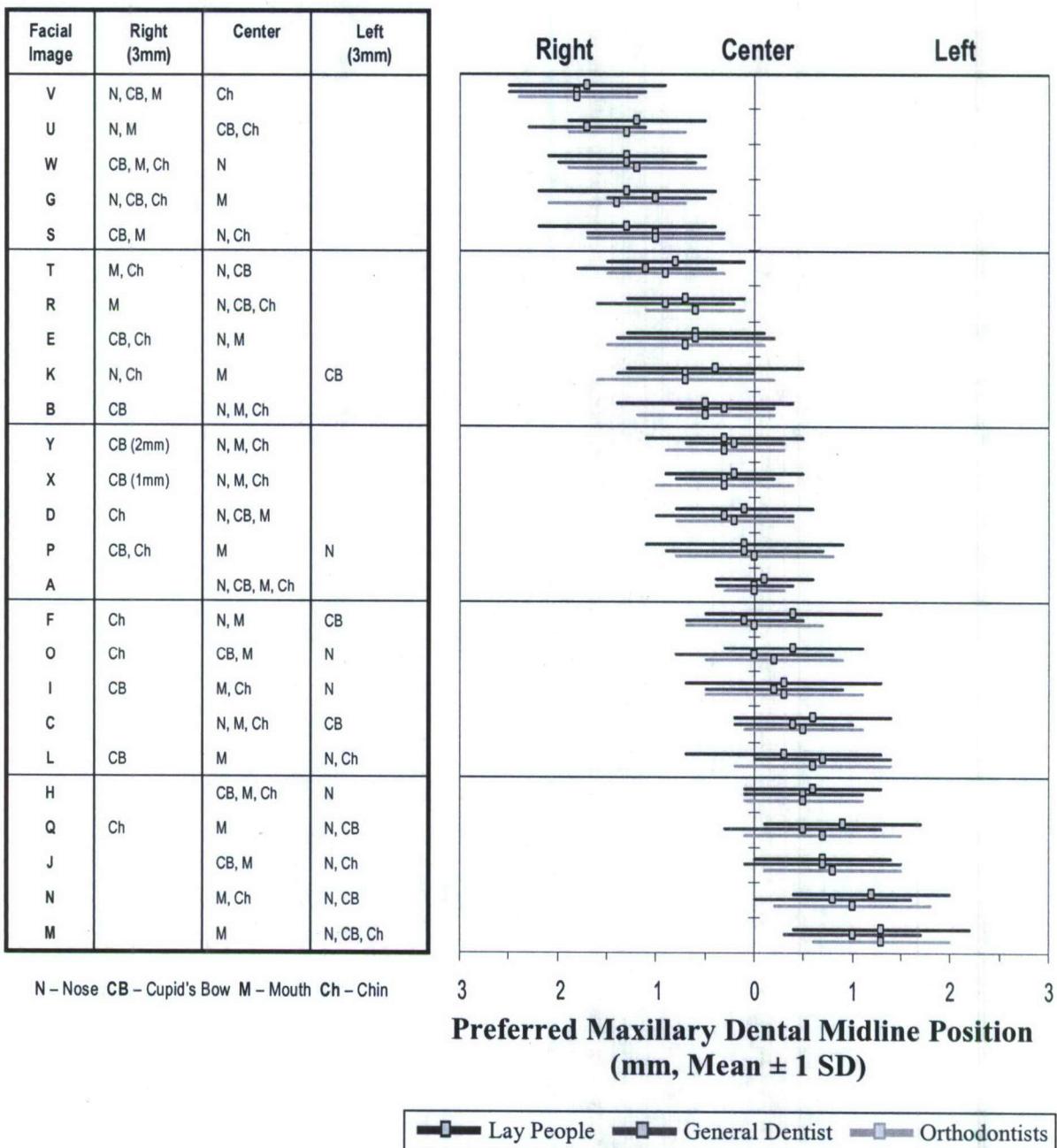
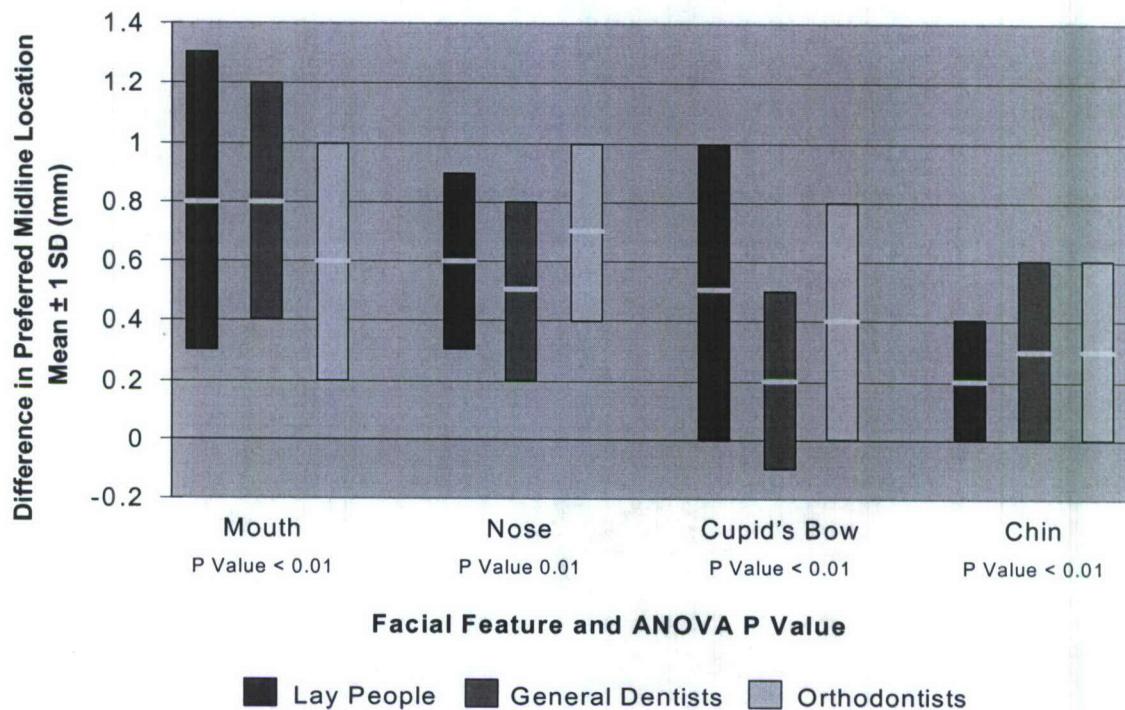


Figure 2.4. Comparison of Average Difference in Preferred Midline Location as a Result of a 3 mm Deviation of Individual Facial Features.



**Comparison of Techniques for Describing the Position of the Maxillary Dental Midline
Relative to the Face in Symmetrical and Asymmetrical Patients**

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3.1 ABSTRACT

Purpose: The purpose of this study was to compare the concordance of twelve techniques for describing the position of the maxillary dental midline relative to the face with respondents' average preferred maxillary dental midline position for a symmetrical face and 22 images in which facial midline structures deviated 3 mm to the right or left. The objective was to identify a technique that could be used to assess the position of the maxillary dental midline in both the symmetrical and asymmetrical patients.

Methods: 277 lay people, general dentists and orthodontists indicated in an internet-based survey where the maxillary dental midline looked best for a series of digitally-altered symmetrical and asymmetrical faces. The difference between the average preferred maxillary dental midline position and the diagnostic reference position of twelve techniques was determined for each facial image. The mean and standard deviation of the differences was calculated for the twelve diagnostic techniques.

Results: All of the diagnostic techniques had excellent agreement with the preferred maxillary dental midline for the symmetrical face. The diagnostic techniques that relied entirely or in part on a deviated facial feature had poor agreement with the average preferred maxillary dental midline position (average difference ranged from 0.9 ± 0.7 mm to 3.3 ± 2.4 mm). A novel technique had the greatest concordance (average difference of 0.1 ± 0.1 mm).

Conclusions: All of the techniques described for assessing the position of the maxillary dental midline can be used for symmetrical patients. For patients with facial

asymmetry, the recommended approaches that rely on only one or two facial features should not be used. Rather, a diagnostic technique that determines the position of the maxillary dental midline based on the position of the nose, cupid's bow, mouth and chin will have the best concordance with the preferred midline location of lay people and dental professionals.

3.2 INTRODUCTION

Dentists routinely assess the position of the maxillary dental midline relative to the face. Many clinicians were taught to do this by comparing the position of the maxillary dental midline to a piece of dental floss stretched from the center of the forehead to the center of the chin. Multiple other techniques have been recommended for describing the position of the maxillary dental midline relative to the face.^{10, 16-24} Like the floss technique, some of these compare the position of the maxillary dental midline to a line connecting two facial features.^{10, 16, 17} Other techniques base the assessment solely on the position of a single facial feature, like the philtrum of the upper lip or the center of the mouth.¹⁸⁻²⁴

All of these techniques work well for patients with symmetrical faces. Unfortunately, a certain degree of facial asymmetry exists in almost all faces³⁻⁹ and the diagnosed position of the maxillary dental midline relative to the face may vary depending on which diagnostic technique is used. For example, the patient in Figure 3.1 has a deviation of cupid's bow to the left and a deviation of the chin to the right. Depending on which diagnostic technique is used, the maxillary dental midline would be diagnosed as deviated 3 mm to the right, not deviated or deviated 3 mm to the left. The concordance of these approaches with lay and professional assessments of the preferred maxillary dental midline given transverse facial asymmetry has not been previously reported in the dental literature.

Lay people, general dentists and orthodontists who participated in an internet-based survey preferred the maxillary dental midline to be altered based on the position of the nose, cupid's bow, mouth and chin.²⁵ The position of the mouth and nose had the greatest influence while the position of the chin and cupid's bow had the least impact on the preferred

position of the maxillary dental midline. Respondents on average did not prefer the dental midline to be aligned directly with any single deviated facial feature.²⁵

The purpose of this study was to compare the concordance of twelve techniques for describing the position of the maxillary dental midline relative to the face with the respondents' average preferred maxillary dental midline position for a symmetrical face and 22 images in which facial midline structures deviated 3 mm to the right or left. The objective was to identify a technique that could be used to assess the position of the maxillary dental midline in both the symmetrical and asymmetrical patients.

3.3 METHODS

Preferred Maxillary Dental Midline Position. From January to October 2007 a total of 277 lay people, general dentists and orthodontists participated in an internet-based survey. The respondents viewed a total of 25 different digitally-altered symmetrical and asymmetrical facial image sets. For each image, respondents were asked to move the maxillary dental midline to the position where they felt the teeth and face looked best. The average preferred maxillary dental midline position was calculated for each facial image. A complete description of the methods was previously reported.²⁵

Images with the facial features centered or altered 3 mm to the left or right were included for analysis in this study. Two facial image sets were excluded from analysis: 1) cupid's bow deviated 1 mm to right, and 2) cupid's bow deviated 2 mm to right.

Techniques for Describing the Position of the Maxillary Dental Midline Relative to the Face. Twelve dental midline diagnostic techniques were evaluated. Five of the techniques were based on extending a vertical line through the center of a single facial feature and six of the techniques were based on a line connecting two facial features (Table 3.1). The location where each reference line passed through the mouth at the level of the maxillary incisal edges was determined for each facial image. (This location was called the diagnostic reference position.) The final technique was a novel approach that calculated the diagnostic reference position for the maxillary dental midline based on the position of the nose, cupid's bow, mouth and chin. The formula and method for calculating the diagnostic reference position is included in the appendix.

Comparison of the Diagnostic Reference Position to the Preferred Maxillary Dental Midline Position. The difference between the diagnostic reference position and the average

preferred maxillary dental midline position was calculated for each facial image. The mean and standard deviation of the difference for the 23 facial images was calculated for each diagnostic technique described in Table 3.1.

3.4 RESULTS

The difference between the diagnostic reference position of the twelve midline diagnostic techniques and the lay people's average preferred maxillary dental midline position for the symmetrical and 22 asymmetrical faces is reported in Table 3.2. As expected, all of the diagnostic techniques had excellent agreement with the lay people's preferred maxillary dental midline for the symmetrical face. However, the concordance varied for the asymmetrical faces and in many cases the difference was greater than 2 mm.

The mean and standard deviation of the difference between the average preferred maxillary dental midline position and the diagnostic reference position of 23 different facial images is reported in Table 3.3 and Figure 3.2. The diagnostic techniques that relied entirely or in part on a deviated facial feature had poor agreement with the average preferred maxillary dental midline position; the average difference ranged from 0.9 ± 0.7 mm to 3.3 ± 2.4 mm. The novel technique had the greatest concordance with an average difference of 0.1 ± 0.1 mm.

3.5 DISCUSSION

The purpose of assessing the position of the maxillary dental midline during a patient evaluation is to identify unaesthetic dental midline deviations and determine where the teeth would look best relative to the face. Multiple techniques have been recommended for describing the position of the maxillary dental midline relative to the face.^{10, 16-24} The validity of these approaches for patients with transverse facial asymmetry is not known, in part, because the ideal or most esthetic position of the maxillary dental midline for patients with facial deviations has not previously been reported. Results of an internet-based survey conducted in 2007 provide insight into a reasonably sized group's (lay people and dental professionals) preferred midline position for patients with transverse facial asymmetry.²⁵ The purpose of this study was to compare the concordance of twelve techniques for describing the position of the maxillary dental midline relative to the face with the respondents' average preferred maxillary dental midline position for a symmetrical face and 22 images in which facial midline structures deviated 3 mm to the right or left.

As expected, all of the diagnostic techniques had excellent agreement with the respondents' preferred maxillary dental midline for the symmetrical face. However, the concordance varied for the asymmetrical faces and in many cases the difference was greater than 2 mm. As a general observation, the diagnostic techniques that relied entirely or in part on a deviated facial feature (2 – 11 in Table 3.1) had poor agreement with the average preferred maxillary dental midline position.

The only diagnostic technique evaluated in this study that did not rely on a deviated facial feature was a vertical line through nasion (1 in Table 3.1). (This reference line coincided with the midsagittal plane.) The diagnostic reference position did not differ by

more than 1.8 mm from the average preferred midline position for any of the facial images and the average difference was $0.7 \text{ mm} \pm 0.5 \text{ mm}$. This technique is based on the assumption that the dental midline looks best centered on the face despite deviations in the position of the nose, cupid's bow, mouth or chin.¹⁵ However, for the facial image with the nose, cupid's bow and mouth deviated 3 mm to the right only 4% of the individuals preferred the maxillary dental midline centered with the face and no individual preferred the dental midline to the left of center.²⁵ Clinicians who rely on this technique should realize that they may be missing an opportunity to camouflage deviated facial features and should make sure the dental midline does not deviate in the opposite direction of the facial asymmetry.

The calculated method had the best concordance with the average preferred maxillary dental midline position. The diagnostic reference position did not differ by more than 0.5 mm from the average preferred midline position for any of the facial images and the average difference was $0.1 \pm 0.1 \text{ mm}$. This technique had excellent concordance considering that a perfect diagnostic test would have an average difference of 0 mm (accurate) $\pm 0 \text{ mm}$ (precise).

Although the calculated method worked well for this set of facial images it is not known if the results can be generalized to other patients. Differences in the size, shape or prominence of facial features between individuals may influence the preferred maxillary dental midline position.¹⁵ Furthermore, there may be additional facial or dental factors that influence people's perception of where the maxillary dental midline position looks best that were not considered. Finally, the facial features in this study all deviated 3 mm from center. Deviations more or less than 3 mm may not have a linear effect on the preferred maxillary dental midline position. Although, it is unlikely that the concordance of the

diagnostic reference position for techniques 1-11 with the preferred dental midline position would be improved at facial deviations greater than 3 mm.

3.6 CONCLUSION

All of the diagnostic techniques had excellent agreement with the respondents' preferred maxillary dental midline for the symmetrical face. For the asymmetrical face, the diagnostic techniques that relied entirely or in part on a deviated facial feature had poor agreement with the average preferred maxillary dental midline position. The diagnostic technique with the best concordance with lay people and dental professional's preferred maxillary dental midline position was a novel approach that determined the diagnostic reference position for the maxillary dental midline based on the position of the tip of the nose, cupid's bow, mouth and chin.

Table 3.1. Midline Diagnostic Techniques Evaluated.

Midline Diagnostic Techniques
1. Vertical Line through Nasion
2. Vertical Line through Nasal Tip
3. Vertical Line through Cupid's Bow
4. Vertical Line through Chin Point
5. Vertical Line through Center of Mouth
6. Line Connecting Nasion-Nasal Tip
7. Line Connecting Nasion-Cupid's Bow
8. Line Connecting Nasion-Chin Point
9. Line Connecting Nasal Tip-Cupid's Bow
10. Line Connecting Nasal Tip-Chin Point
11. Line Connecting Cupid's Bow-Chin Point
12. Calculated Midline

Table 3.2. Comparison of the Diagnostic Reference Position of Twelve Midline Diagnostic Techniques with the Lay People's Average Preferred Maxillary Dental Midline Position for a Symmetrical Face and 22 Asymmetrical Faces.

Position of Facial Features (N – Nose, CB – Cupid's Bow, M – Mouth, Ch – Chin)		Difference Between Diagnostic Reference Position and Lay People's Average Preferred Maxillary Midline Position (mm)											
		1	2	3	4	5	6	7	8	9	10	11	12
3mm Right	Centered	3mm Left											
N,CB,M,Ch	N,M,Ch	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
N,M,Ch	CB	0.5	0.5	2.5	0.5	0.5	0.5	3.5	0.5	4.0	0.5	1.5	0.0
N,M,Ch	N,CB,M	0.6	0.6	2.4	0.6	0.6	0.6	3.4	0.6	3.9	0.6	1.4	0.1
N,CB,M	CB	0.1	0.1	0.1	2.9	0.1	0.1	0.1	2.4	0.1	1.9	0.9	0.2
N,M	N,M	0.6	0.6	2.4	2.4	0.6	0.6	3.4	1.9	3.9	1.4	2.4	0.2
N,CB,Ch	CB	0.4	0.4	2.6	3.4	0.4	0.4	3.6	2.9	4.1	2.4	0.6	0.2
CB,M,Ch	N	1.3	1.7	1.7	1.7	1.3	4.7	2.7	1.2	1.7	1.7	1.7	0.1
CB,M,Ch	CB	0.6	2.4	0.6	0.6	5.4	0.6	0.6	2.1	0.4	0.6	0.6	0.1
M,Ch	N	0.3	2.7	3.3	0.3	0.3	5.7	4.3	0.3	6.3	0.7	2.3	0.3
CB,M	N,Ch	0.7	2.3	0.7	2.3	0.7	5.3	0.7	1.8	2.2	2.3	0.3	0.1
M	CB	0.4	2.6	3.4	2.6	0.4	5.6	4.4	2.9	6.4	2.6	1.4	0.2
M	N,Ch	0.3	2.7	3.3	2.7	0.3	5.7	4.3	2.8	6.3	2.7	1.3	0.1
M	N,CB,Ch	1.3	1.7	1.7	1.7	1.3	4.7	2.7	1.2	1.7	1.7	1.7	0.1
M,Ch	N,CB	1.2	1.8	1.8	1.2	1.2	4.8	2.8	1.2	1.8	0.2	0.8	0.2
CB,M	N	0.4	2.6	0.4	3.4	0.4	5.6	0.4	2.9	1.9	0.9	1.4	0.2
M	N	0.1	3.1	2.9	2.9	0.1	6.1	3.9	2.4	5.9	0.4	2.9	0.2
Ch	M,N,CB	0.9	2.1	2.1	3.9	0.9	5.1	3.1	3.4	2.1	1.4	0.1	0.2
M	N,CB,Ch	0.7	0.7	0.7	0.7	2.3	0.7	0.7	0.7	0.7	0.7	0.7	0.1
CB,M	N,Ch	1.3	1.3	1.7	1.3	1.7	1.3	2.7	1.3	3.2	1.3	0.7	0.1
M,Ch	N,CB	0.8	0.8	0.8	2.2	2.2	0.8	0.8	1.7	0.8	1.2	0.2	0.2
N,M	CB,Ch	1.2	1.8	1.2	1.2	1.8	4.8	1.2	1.2	2.7	0.2	1.2	0.1
N,CB,M	Ch	1.7	1.3	1.3	1.7	1.3	4.3	2.3	1.7	1.3	0.7	0.3	0.1
CB,M,Ch	N	1.3	1.3	1.7	1.7	1.7	1.3	2.7	1.2	3.2	0.7	1.7	0.2

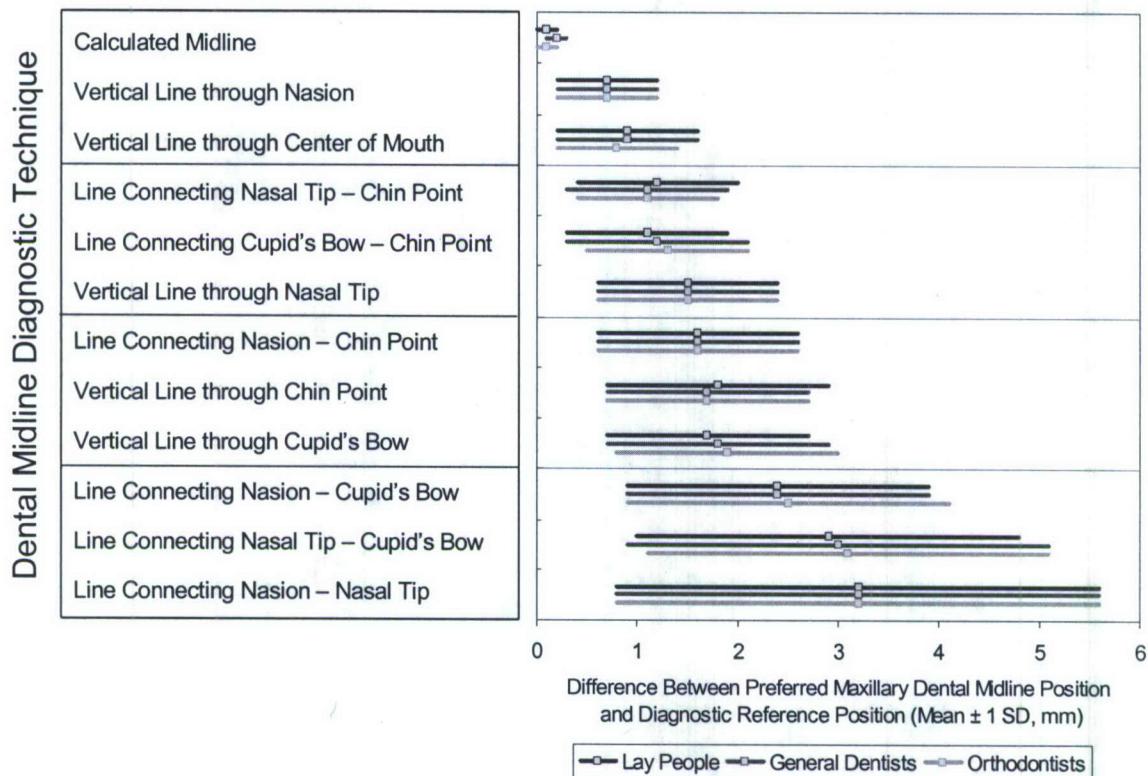
Table 3.3. Concordance of Twelve Dental Midline Diagnostic Techniques with the Average Preferred Maxillary Dental Midline Position. The mean and standard deviation of the difference between the average preferred maxillary dental midline position and the diagnostic reference position of 23 different facial images is reported. The mean reflects accuracy and the standard deviation reflects precision; the closer the values to zero the more accurate and precise the diagnostic test.

Midline Diagnostic Technique	Lay People		General Dentists		Orthodontists	
	Mean \pm SD (mm)	Min – Max (mm)	Mean \pm SD (mm)	Min – Max (mm)	Mean \pm SD (mm)	Min – Max (mm)
Vertical Line through Nasion	0.7 \pm 0.5	0.1 – 1.7	0.7 \pm 0.5	0.0 – 1.8	0.7 \pm 0.5	0.0 – 1.8
Vertical Line through Nasal Tip	1.5 \pm 0.9	0.1 – 3.1	1.5 \pm 0.9	0.0 – 3.0	1.5 \pm 1.0	0.0 – 3.0
Vertical Line through Cupid's Bow	1.7 \pm 1.0	0.1 – 3.4	1.8 \pm 1.1	0.0 – 3.7	1.9 \pm 1.1	0.0 – 3.7
Vertical Line through Chin Point	1.8 \pm 1.1	0.1 – 3.9	1.7 \pm 1.0	0.0 – 3.7	1.7 \pm 1.0	0.0 – 3.5
Vertical Line through Center of Mouth	0.9 \pm 0.7	0.1 – 2.3	0.9 \pm 0.7	0.0 – 2.4	0.8 \pm 0.6	0.0 – 2.1
Line Connecting Nasion-Nasal Tip	3.3 \pm 2.4	0.1 – 6.1	3.2 \pm 2.4	0.0 – 6.0	3.2 \pm 2.4	0.0 – 6.0
Line Connecting Nasion-Cupid's Bow	2.3 \pm 1.4	0.1 – 4.3	2.4 \pm 1.5	0.0 – 4.7	2.5 \pm 1.6	0.0 – 4.7
Line Connecting Nasion-Chin Point	1.6 \pm 1.0	0.1 – 3.4	1.6 \pm 1.0	0.0 – 3.2	1.6 \pm 1.0	0.0 – 3.2
Line Connecting Nasal Tip-Cupid's Bow	2.8 \pm 2.0	0.1 – 6.4	3.0 \pm 2.1	0.0 – 6.7	3.1 \pm 2.0	0.0 – 6.7
Line Connecting Nasal Tip-Chin Point	1.2 \pm 0.8	0.1 – 2.7	1.1 \pm 0.8	0.0 – 2.7	1.1 \pm 0.7	0.0 – 2.3
Line Connecting Cupid's Bow-Chin Point	1.1 \pm 0.8	0.1 – 2.9	1.2 \pm 0.9	0.0 – 3.7	1.3 \pm 0.8	0.0 – 3.1
Calculated Midline	0.1 \pm 0.1	0.0 – 0.3	0.2 \pm 0.1	0.0 – 0.5	0.1 \pm 0.1	0.0 – 0.4

Figure 3.1. A. Patient with cupid's bow deviated slightly to her left and the chin deviated slightly to her right. B. Illustration of three different techniques for relating the maxillary dental midline to the face: Line from nasion to center of chin (Blue, Technique 11 in Table 3.1); Vertical line through nasion (Black, Technique 1 in Table 3.1); and Line from nasion through cupid's bow (Red, Technique 7 in Table 3.1).



Figure 3.2. Comparison of Twelve Dental Midline Diagnostic Techniques. The mean and standard deviation of difference between the average preferred maxillary dental midline position and the diagnostic reference position of 23 different facial images is reported. The mean reflects accuracy and the standard deviation reflects precision; the closer the values to zero the more accurate and precise the diagnostic test.



4. CONCLUSION

The position of the maxillary dental midline was moved by respondents in response to changes in the position of the tip of the nose, cupid's bow, mouth and chin. Respondents moved the maxillary dental midline most to compensate for discrepancies in the position of the mouth and nose and least for the chin and cupid's bow. There was not a one to one correlation between the preferred position of the maxillary dental midline and any single facial feature. There was generally good agreement between the lay people, general dentists and orthodontists in their perceptions. Although some of the differences between the respondent groups were statistically significant these differences were quite small and not likely to be clinically significant.

All of the diagnostic techniques had excellent agreement with the respondents' preferred maxillary dental midline for the symmetrical face. For the asymmetrical face, the diagnostic techniques that relied entirely or in part on a deviated facial feature had poor agreement with the average preferred maxillary dental midline position. The diagnostic technique with the best concordance with lay people and dental professional's preferred maxillary dental midline position was a novel approach that determined the diagnostic reference position for the maxillary dental midline based on the position of the tip of the nose, cupid's bow, mouth and chin. Clinicians should view the full face and consider the position of the nose, cupid's bow, mouth and chin when diagnosing the position of the maxillary dental midline.

APPENDIX

The calculated diagnostic reference position was determined by the formula:

$$\text{Maxillary Dental Midline Position} = N(\bar{X}_N) + CB(\bar{X}_{CB}) + M(\bar{X}_M) + Ch(\bar{X}_{Ch})$$

The value of the variables N, CB, M or Ch were “0” if the nose, cupid’s bow, mouth or chin were centered on the face, “1” if the respective facial features were deviated 3 mm to the left and “-1” if the respective facial features were deviated 3 mm to the right. The coefficients \bar{X}_N , \bar{X}_{CB} , \bar{X}_M and \bar{X}_{Ch} were the values for the average change in the maxillary dental midline position as a result of a 3 mm change in the position of the respective facial features.²⁵ These values were based primarily on the responses of both the lay people and dental professionals but adjusted for easier clinical use. The respective values used were 0.5 mm, 0.5 mm, 0.7 mm and 0.3 mm.

$$\text{Maxillary Dental Midline Position (mm)} = N(0.5) + CB(0.5) + M(0.7) + Ch(0.3)$$

A positive value for the “Maxillary Dental Midline Position” indicated a preferred location to the left of center and a negative value indicated a preferred position to the right of center. Center referred to the midsagittal plane which in this sample of asymmetrical images was coincident with a vertical line through glabella, nasion and the mid-interpupillary point.

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